

(19) World Intellectual Property  
Organization  
International Bureau



(43) International Publication Date  
14 October 2004 (14.10.2004)

PCT

(10) International Publication Number  
**WO 2004/087986 A1**

(51) International Patent Classification<sup>7</sup>: **C23C 14/30**,  
H01J 37/305

(74) Agent: **HANSON, William, Bennett**; Bromhead Johnson, Kingsbourne House, 229-231 High Holborn, London WC1V 7DP (GB).

(21) International Application Number:  
PCT/GB2004/001469

(22) International Filing Date: 2 April 2004 (02.04.2004)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:  
0307745.0 3 April 2003 (03.04.2003) GB

(71) Applicant (for all designated States except US): **MI-CROEMISSIVE DISPLAYS LIMITED** [GB/GB]; Scottish Microelectronics Centre, The King's Buildings, West Mains Road, Edinburgh EH9 3JF (GB).

(72) Inventor; and

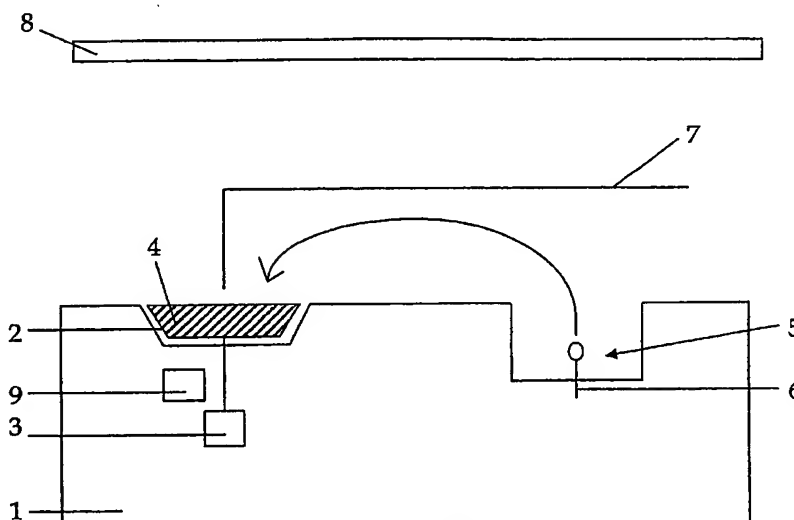
(75) Inventor/Applicant (for US only): **BUCKLEY, Alastair, Robert** [GB/GB]; Flat 2F2, 92 Montpelier Park, Edinburgh EH10 4NG (GB).

(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NA, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LS, MW, MZ, SD, SI, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

[Continued on next page]

(54) Title: METHOD AND APPARATUS FOR DEPOSITING MATERIAL ON A SUBSTRATE



(57) Abstract: Material (4) is deposited on a substrate (8) by arranging the material in a container (2), and contacting the surface of the material (4) with a beam of electrons to so as to evaporate the material and transfer it to the substrate. A shield (7) opaque to electrons is arranged to cover a portion of the surface contacted by the beam of electrons. Relative movement occurs between the container (2) on one hand and the shield (7) and the beam of electrons on the other hand such that the portion of the surface previously contacted by the beam of electrons is no longer covered by the shield and is exposed to the substrate (8).

WO 2004/087986 A1



**Published:**

- with international search report
- before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments

*For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.*

METHOD AND APPARATUS FOR DEPOSITING  
MATERIAL ON A SUBSTRATE

Background to the Invention

- 5 This invention relates to a method and apparatus for depositing material on a substrate.

The invention is particularly, but not exclusively, applicable to the deposition of an encapsulating material on a substrate already bearing sensitive material. For example, a semiconducting substrate bearing an array of organic light emitting diodes (OLEDs) may have a top electrode comprising a layer of low work function material such as calcium. Calcium is extremely reactive with oxygen and water and it is therefore required to coat the calcium layer with an encapsulating layer, for example of aluminum oxide or silicon dioxide, in order to prevent the ingress of oxygen and water.

One method of deposition of the encapsulating material which has been suggested is electron beam evaporation. This involves causing a hot filament to emit electrons, which impact the surface of the encapsulating material contained in a crucible. Under a high vacuum the electrons cause the encapsulating material to be evaporated and transferred to the substrate.

A major disadvantage of electron beam evaporation is the presence of secondary electrons which are emitted from the encapsulating material. These secondary electrons would damage polymeric layers of an OLED such as to render useless any OLED device sought to be fabricated.

Magnetic fields have been suggested as a means of confining the secondary electrons. However, magnetic fields are ineffective when the surface of the

encapsulating material in the crucible is rough or when the secondary electrons have a wide range of energies and/or directions.

### Summary of the Invention

- 5 It is an aim of the invention to provide a method of depositing material on a substrate using electron beam evaporation in which damage to the substrate caused by secondary electrons is prevented or minimized.

10 Accordingly, the invention provides a method of depositing material on a substrate comprising the steps of arranging the material to be deposited in a container such that the material has a free surface, and contacting said surface with a beam of electrons to so as to evaporate the material and transfer the material to the substrate, a shield opaque to electrons being arranged to cover a portion of the surface contacted by said beam of  
15 electrons, and causing relative movement between the container on one hand and the shield and the beam of electrons on the other hand such that said portion of the surface previously contacted by the beam of electrons is no longer covered by the shield and is exposed to the substrate.

- 20 The shield prevents secondary electrons from reaching the substrate, and material is evaporated from a portion of the surface not actually contacted by the beam of electrons but still subject to residual heat by virtue of having been so contacted previously.

- 25 The relative movement may in particular comprise relative rotation and the container may be moved whilst the shield and beam of electrons are held stationary.

- 30 If the residual heat from the beam of electrons is insufficient, the material may be heated by a heat source additional to the beam of electrons.

The invention also provides apparatus for depositing material on a substrate, comprising a container for containing the material to be deposited, an electron gun for contacting the material with a beam of electrons so as to evaporate the material and transfer the material to the substrate, a shield  
5 opaque to electrons arranged to cover a portion of the container, and means for causing relative movement between the container on one hand and the shield and the electron gun on the other hand.

The means for causing relative movement may in particular comprise means  
10 for rotating the container about an axis.

The apparatus may comprise means for heating the material, additional to the electron gun.

#### 15 Brief Description of the Drawing

In order that the invention may be more readily understood, reference will now be made, by way of example only, to the accompanying drawing, the single figure of which is a schematic view of apparatus according to an embodiment of the invention.

20

#### Detailed Description of a Particular Embodiment

The drawing shows apparatus comprising a platform 1 on which a crucible 2 is arranged for rotation about an axis, driven by means such as an electric motor 3. A known electron beam evaporation apparatus comprises a  
25 turntable which rotates such that different materials can be selected for evaporation. According to the invention, this turntable is replaced by the crucible 2. The crucible 2 contains an encapsulating material 4.

An electron gun 5 comprises a filament 6 which emits an electron beam,  
30 represented by the arrow. A shield 7 covers a portion (e.g. half) of the

surface of the material 4 in the crucible 2, and the electron beam is incident on this portion. All of the secondary electrons emitted from the material are trapped by the shield 7.

- 5 The portion of the surface of the material 4 not covered by the shield 7 faces a substrate 8. Material evaporated from this exposed portion of the surface is transferred to the substrate 8.

- 10 An optional supplementary heat source 9, such as an electrical heat source, may be provided for heating the material 4.

All forms of the verb "to comprise" used in this specification have the meaning "to consist of or include".

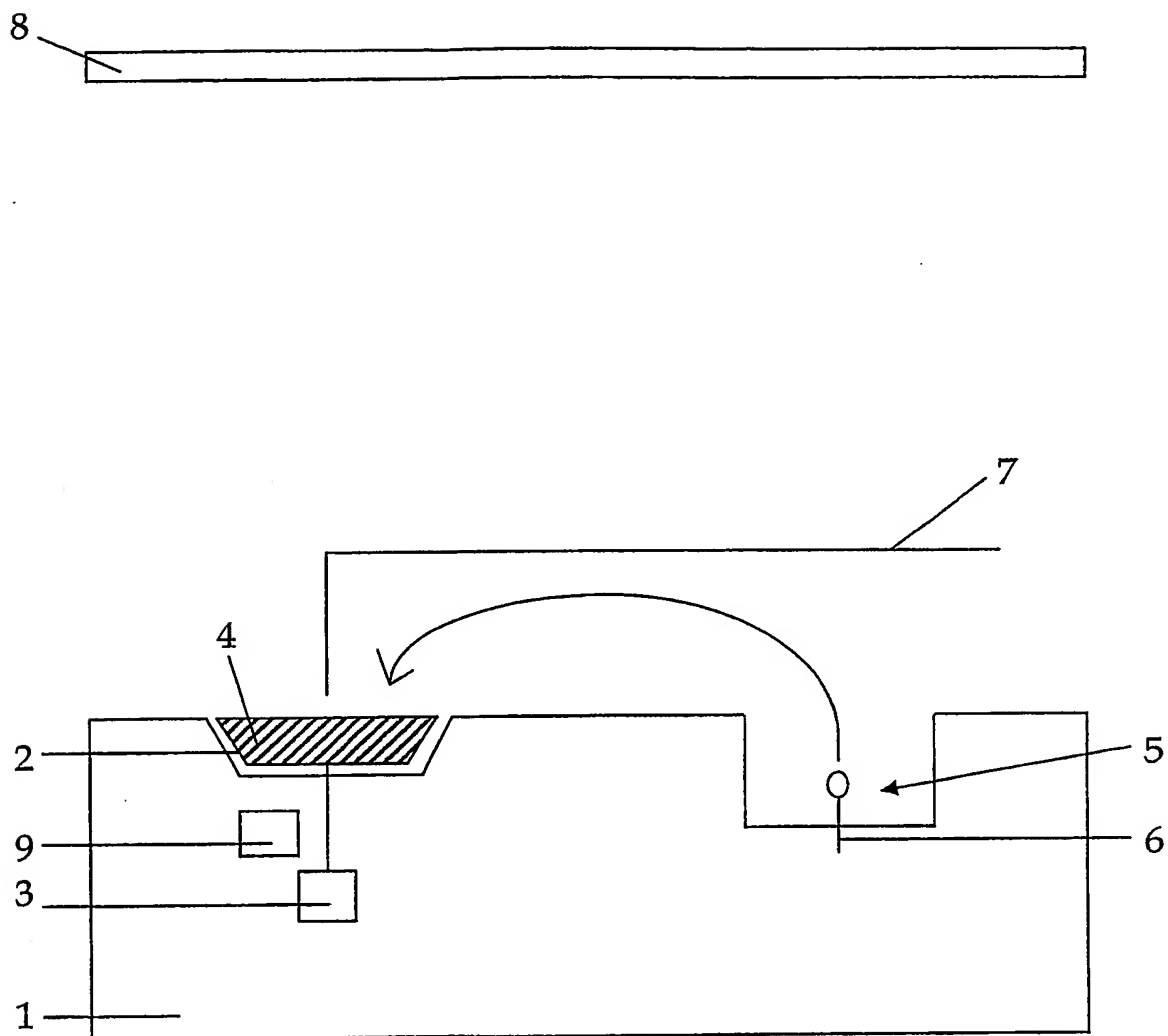
## CLAIMS

1. A method of depositing material on a substrate comprising the steps of arranging the material to be deposited in a container such that the material  
5 has a free surface, and contacting said surface with a beam of electrons to so as to evaporate the material and transfer the material to the substrate, a shield opaque to electrons being arranged to cover a portion of the surface contacted by said beam of electrons, and causing relative movement between the container on one hand and the shield and the beam of electrons on the  
10 other hand such that said portion of the surface previously contacted by the beam of electrons is no longer covered by the shield and is exposed to the substrate.
2. A method according to claim 1, wherein the relative movement  
15 comprises relative rotation.
3. A method according to claim 2, wherein the container is moved whilst the shield and beam of electrons are held stationary.
- 20 4. A method according to claim 1, 2 or 3, comprising heating the material by means of a heat source additional to the beam of electrons.
5. Apparatus for depositing material on a substrate, comprising a container for containing the material to be deposited, an electron gun for  
25 contacting the material with a beam of electrons so as to evaporate the material and transfer the material to the substrate, a shield opaque to electrons arranged to cover a portion of the container, and means for causing relative movement between the container on one hand and the shield and the electron gun on the other hand.

6. Apparatus according to claim 5, wherein the means for causing relative movement comprises means for rotating the container about an axis.

7. Apparatus according to claim 5 or 6, comprising means for heating the  
5 material, additional to the electron gun.

1/1



# INTERNATIONAL SEARCH REPORT

In **national Application No**  
**FR 032004/001469**

<b>A. CLASSIFICATION OF SUBJECT MATTER</b> IPC 7 C23C14/30 H01J37/305		
According to International Patent Classification (IPC) or to both national classification and IPC		
<b>B. FIELDS SEARCHED</b> Minimum documentation searched (classification system followed by classification symbols) IPC 7 C23C H01J		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the International search (name of data base and, where practical, search terms used) EPO-Internal, INSPEC, PAJ		
<b>C. DOCUMENTS CONSIDERED TO BE RELEVANT</b>		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 303 694 A (BOIS DANIEL) 1 December 1981 (1981-12-01) the whole document	1-4
X	US 4 748 935 A (WEGMANN URS) 7 June 1988 (1988-06-07) column 4, line 32 - column 5, line 14; figure 1	5-7
X	EP 1 160 351 A (BOC GROUP INC) 5 December 2001 (2001-12-05) column 6, paragraph 19 - column 7, paragraph 22; figures 2,3	5-7
A	US 5 785 763 A (HORI YASUKO ET AL) 28 July 1998 (1998-07-28) column 4, line 43 - column 8, line 50; figures 2-6	1
-/-		
<input checked="" type="checkbox"/> Further documents are listed in the continuation of box C. <input checked="" type="checkbox"/> Patent family members are listed in annex.		
* Special categories of cited documents : *A* document defining the general state of the art which is not considered to be of particular relevance *E* earlier document but published on or after the International filing date *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) *O* document referring to an oral disclosure, use, exhibition or other means *P* document published prior to the International filing date but later than the priority date claimed *T* later document published after the International filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art *Z* document member of the same patent family		
Date of the actual completion of the International search 2 August 2004		Date of mailing of the International search report 12/08/2004
Name and mailing address of the ISA European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016		Authorized officer Joffreau, P-O

# INTERNATIONAL SEARCH REPORT

In - onal Application No  
F01/ GB2004/001469

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT		
Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	PATENT ABSTRACTS OF JAPAN vol. 0100, no. 04 (C-322), 9 January 1986 (1986-01-09) & JP 60 165374 A (MATSUSHITA DENSHI KOGYO KK), 28 August 1985 (1985-08-28) abstract	1
A	PATENT ABSTRACTS OF JAPAN vol. 0100, no. 04 (C-322), 9 January 1986 (1986-01-09) & JP 60 165373 A (MATSUSHITA DENSHI KOGYO KK), 28 August 1985 (1985-08-28) abstract	1
A	PATENT ABSTRACTS OF JAPAN vol. 0100, no. 31 (C-327), 6 February 1986 (1986-02-06) & JP 60 181265 A (NIPPON DENSHIN DENWA KOSHA), 14 September 1985 (1985-09-14) abstract	1

# INTERNATIONAL SEARCH REPORT

onal Application No  
PCT/GB2004/001469

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 4303694	A	01-12-1981	FR 2455634 A1 CH 637168 A5 GB 2049739 A , B	28-11-1980 15-07-1983 31-12-1980
US 4748935	A	07-06-1988	CH 663037 A5 DE 3506671 A1 FR 2576918 A1 GB 2170823 A , B JP 2510986 B2 JP 61183461 A	13-11-1987 07-08-1986 08-08-1986 13-08-1986 26-06-1996 16-08-1986
EP 1160351	A	05-12-2001	US 6342103 B1 EP 1160351 A2 JP 2002038256 A US 2002040682 A1	29-01-2002 05-12-2001 06-02-2002 11-04-2002
US 5785763	A	28-07-1998	JP 2655094 B2 JP 8067970 A	17-09-1997 12-03-1996
JP 60165374	A	28-08-1985	NONE	
JP 60165373	A	28-08-1985	NONE	
JP 60181265	A	14-09-1985	NONE	